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Combining Input-Output and Regression Analysis in Projection Models: An Application to Agriculture

By Gerald Schluter

Grafting an adjustment equation onto an input-output based projection model improves the predictive performance of the unadjusted model and results in a relatively sensitive estimator of both the level of and changes in nominal and real gross farm product.

Keywords: Input-output analysis, farm income, projection, models.

Despite the logical appeal of the "consistent" forecasts[1] which result from input-output models, this technique remains largely unexploited by agricultural economists in their projection work. This disregard has not occurred without reason. Input-output (I/O) based projection models often overestimate the output of agricultural sectors. Many input-output tables are, to varying degrees, out of date by the time they are constructed, and the adequate specification of a final demand vector for the target year is a formidable task in itself. These are all serious problems, but if several variations are made in the usual I/O projection procedures, an I/O based model can do a reasonably good job of predicting agriculture's contribution to U.S. gross national product.

Projection with an input-output model is mechanically simple. A projected final demand vector (Y) is premultiplied by an $(I\text{-}A)^{-1}$ or total requirement matrix to yield a vector of gross outputs by sector, i.e.,

$$(1)\quad X = (I\text{-}A)^{-1}Y$$

The gross output calculated from equation (1) involves varying degrees of multiple counting. Actual gross national product generated in the individual sectors can be calculated by premultiplying the gross output vector (X) by a diagonal matrix with the individual value-added coefficients on the diagonal.

$$(2)\quad GNP = VX = V(I\text{-}A)^{-1}Y$$

Difficulties arise in trying to specify an adequate representation of the total requirement matrix and final demand vector. If one is willing to assume a stable relative price, product mix, and technological structure from the year the latest input-output matrix was constructed until the target year, one may simply use the corresponding total requirement matrix in the projection model. When these assumptions are not appropriate or there exists empirical evidence of changes in one of these conditions, the performance of the projection model may be improved by updating the input-output matrix to incorporate these changes.[2]

Several attributes of final demand vectors complicate their accurate specification. Final demand vectors are usually specified in terms of producer's value, that is, that part of their final value not represented by trade or transportation margins. This is a difficult estimation problem which is usually dealt with product by product in the construction of an input-output matrix. The failure to devote equivalent attention to this problem in specifying a projected final demand vector is a possible source of estimating errors in input-output projection models.

A second characteristic of final demand vectors which complicates their accurate specification is the necessity of specifying projections of consumer and Government spending, foreign trade transactions, and inventory and private investment expenditures in terms of specific sector or industry categories. This is time consuming and

[1] Consistency means that the sum of all the estimates of individual sector incomes is equal to the total income in the economy.

[2] Schaffer (*2*) provides a good discussion of the relative merits of various techniques for updating an input-output matrix.

unfortunately the lack of proper data sources often dictates arbitrary classification decisions.

A Simplified I/O Projection Technique

With the simplifying assumptions of (1) stable input-output coefficients during the projection period and (2) a regular and systematic division of demand from final demand among producing sectors, a projection model was built based on the 363-sector input-output model of the 1963 U.S. economy (*4*). This model avoids the work and problems associated with specifying a detailed final demand vector and the cumbersome problem of handling a 363-sector inverse.

The computational procedure for calculating the model coefficients implicitly views each component of the Nation's income and product accounts as a separate final demand sector. In equation (1) an $n \times 1$ vector of gross outputs is calculated by premultiplying a vector of final demands by the total requirements matrix. Let us expand this analysis so there are m final demand sectors as well as the n producing sectors. Denote by Y_t the n-component column vector of deliveries to final demand at time t, organized by producing sector of origin. Let Z_t be the m-component vector of deliveries to final demand at time t, organized by final demand sector. The sum of the components of each vector is the same, since each represents a different way of expressing total final demand. Thus, if h_k denotes a k-component row vector of unit elements,

$$(3)\quad h_n Y_t = h_m Z_t$$

By assumption 2 above we can express the relationship between Y_t and Z_t as

$$(4)\quad Y_t = BZ_t + u_t$$

where B is an $n \times m$ constant matrix parameter and u_t is an n-component disturbance vector. Since each column of B represents the distribution of a particular component of final demand over consuming sectors and since each such component must be exactly distributed, each column of B must sum to unity. Thus:

$$(5)\quad h_n B = h_m$$

and, in view of equations (3) and (4),

$$(6)\quad h_n u_t = h_n (Y_t - BZ_t) = h_n Y_t - h_m Z_t = 0$$

Thus the disturbances sum to zero across all equations.

The data for estimating a B matrix for 1963 are available from published U.S. Department of Commerce sources. The personal consumption expenditures data are available for up to 82 components from (*5*) and detail for the rest of the final demand sector is available from supplements to (*4*).

From equations (2), (4), and (6),

$$(7)\quad GNP = V(I - A)^{-1} BZ_t$$

for the whole economy. By assumptions 1 and 2 the matrices V, $(I - A)^{-1}$, and B are all constant so their $n \times m$ matrix product will also be constant.

$$(8)\quad C = V(I - A)^{-1} B$$

Element c_{ij} of matrix C is interpreted as the gross national product generated in producing sector i per dollar of expenditure in final demand sector j. This type of computation was performed for the 10 agricultural production sectors of the 363-sector I/O table and for 22 final demand components. The aggregated results of this computation expressed in 1958 dollars are presented in table 1.[3]

The cumulative multiplication of the coefficients in table 1 times the corresponding components of the national income and product accounts for a given year yields an estimate of gross national product originating in farming for that year.[4] This statistic is commonly referred

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[3] If the 10 agricultural production rows of C were aggregated to one row, then the coefficients in table 1 (expressed in 1963 dollars) would be the agricultural production row of the new 354×22 C matrix. For the interested reader the 10×22 C matrix for agricultural production is published in (*3*, table 2).

[4] Actual national income and product account data in constant dollars were used. This approach, equivalent to assuming that a method exists for projecting GNP and its components with no error, makes it possible to evaluate the relative merits of the different projection methods independent of errors associated with GNP projections. In fact, the most useful application of the models investigated in this paper may be to analyze the implications for the farming sector of economic projections of the larger econometric models, such as the Brookings model.

Table 1. Gross farm product generated per dollar of expenditure in selected components of the national income and product accounts, 1963
(In 1958 dollars)

Item	Value[a]
1. Autos and parts (PCE)[b]	.00339
2. Furniture and household equipment (PCE)	.00519
3. Other durables (PCE)	.00912
4. Food purchased for off-premise consumption (PCE)	.17311
5. Purchased meals and beverages (PCE)	.11573
6. Food furnished Government and commercial employees and consumed in farm households (PCE)	.35534
7. Shoes and other footwear (PCE)	.00613
8. Clothing (PCE)	.02607
9. Gasoline and oil (PCE)	.00441
10. Tobacco products (PCE)	.08644
11. Other nondurables (PCE)	.02149
12. Housing services (PCE)	.02542
13. Household operation services (PCE)	.00161
14. Transportation services (PCE)	.00314
15. Other services (PCE)	.00768
16. Producers durable equipment	.00399
17. Structure investment	.01051
18. Change in farm inventories	.67023
19. Change in nonfarm inventories	.04254
20. Gross exports	.08639
21. Federal Government purchases of goods and services	.00262
22. State and local government purchases of goods and services	.00672

[a]Derived from U.S. Department of Commerce data.
[b]PCE = personal consumption expenditures.

to as gross farm product. Estimated gross farm product in current and constant dollars is reported each year in the National Income issue of *Survey of Current Business* (*6*). It is calculated as the sum of gross farm income and some minor adjustments, less value of intermediate products consumed and gross rents paid to nonfarm operator landlords. The official constant dollar gross farm product series and the I/O based model predictions are presented in table 2 and figure 1 for 1949-72. Table 2 and figure 2 present the annual changes in gross farm product and the I/O based model estimates of changes in this statistic.

The obvious weakness of this type of model is its basis on the economic relationships existing in only one year, 1963. If in fact there were continuing changes in relative prices, relative growth rates in productivity, and other normal characteristics of a dynamic economy, or if some economic situation were unique to the base year, the former are ignored and the latter is considered. One would expect that the further one gets from the base year, the poorer the results would be. A comparison of the actual and I/O based model prediction lines in figure 1 and table 2 provides evidence of this influence in the present model also. This model consistently overestimates gross farm product since 1964. Figure 2 and table 2 show that the I/O based model also is inadequate as a predictor of year-to-year changes in constant dollar gross farm product. This model predicted none of the eight decreases in this statistic during 1949-72 and erroneously predicted a decrease during 1951-53. With a calculated Theil's U^2 statistic[5] of 1.38, this model is inferior to even the naive "no-change" prediction procedure (U^2 = 1.0)

[5] $$U^2 = \frac{\sum_{i=1}^{n}(P_i - A_i)^2}{\sum_{i=1}^{n} A_i^2}$$

where (P_i, A_i) are a pair of predicted and observed changes in an economic series.

as a predictor of yearly changes in constant dollar gross farm product.

The deficiencies of this I/O based model as a predictor of both the level and the changes in gross farm product are obvious. It is also obvious that the estimation procedures presented thus far, while simpler to implement than traditional input-output estimation procedures, have contributed little to improving the quality of the predictions. An attempt to deal with this problem is explored in the next section.

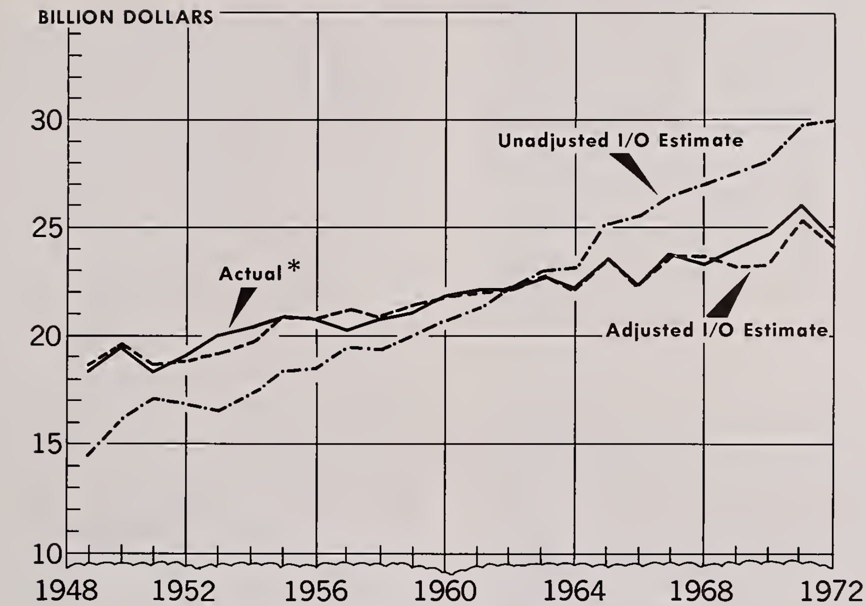
Table 2. Constant dollar gross farm product: Actual series, I/O model estimates, and adjusted I/O model estimates, level and annual changes, 1949-72

(In billions of dollars)

Year	Level			Changes		
	Actual[a]	Unadjusted I/O-based Model	Adjusted I/O-based Model	Actual	Unadjusted I/O-based Model	Adjusted I/O-based Model
1949	18.4	14.5	18.6			
1950	19.4	16.2	19.6	1.0	1.7	1.0
1951	18.4	17.1	18.7	−1.0	.9	−.9
1952	19.0	16.9	18.9	.6	−.2	.2
1953	20.0	16.5	19.1	1.0	−.4	.2
1954	20.4	17.3	19.7	.4	.8	.6
1955	20.9	18.4	20.9	.5	1.1	1.2
1956	20.8	18.5	20.8	−.1	.1	−.1
1957	20.3	19.5	21.3	−.5	1.0	.5
1958	20.8	19.4	20.9	.5	−.1	−.4
1959	21.1	20.0	21.4	.3	.6	.5
1960	21.9	20.7	21.9	.8	.7	.5
1961	22.2	21.3	21.9	.3	.6	0
1962	22.1	22.2	22.2	−.1	.9	.3
1963	22.8	22.9	22.8	.7	.7	.6
1964	22.3	23.2	22.2	−.5	.3	−.6
1965	23.7	25.2	23.6	1.4	2.0	1.4
1966	22.4	25.6	22.4	−1.3	.4	−1.2
1967	23.9	26.5	23.7	1.5	.9	1.3
1968	23.4	27.1	23.6	−.5	.6	−.1
1969	24.1	27.5	23.2	.7	.4	−.4
1970	24.8	28.3	23.4	.7	.8	.2
1971	26.0	29.8	25.4	1.2	1.5	2.0
1972	24.6	30.0	24.3	−1.4	.2	−1.1
RMSPE:						
1949-68		2.29	.37		.93	.44
1969-72		4.11	.90		.83	.74
U^2:						
1949-68					1.38	.31
1969-72					.63	.50

[a]Source: U.S. Department of Commerce, *Survey of Current Business*, various issues.

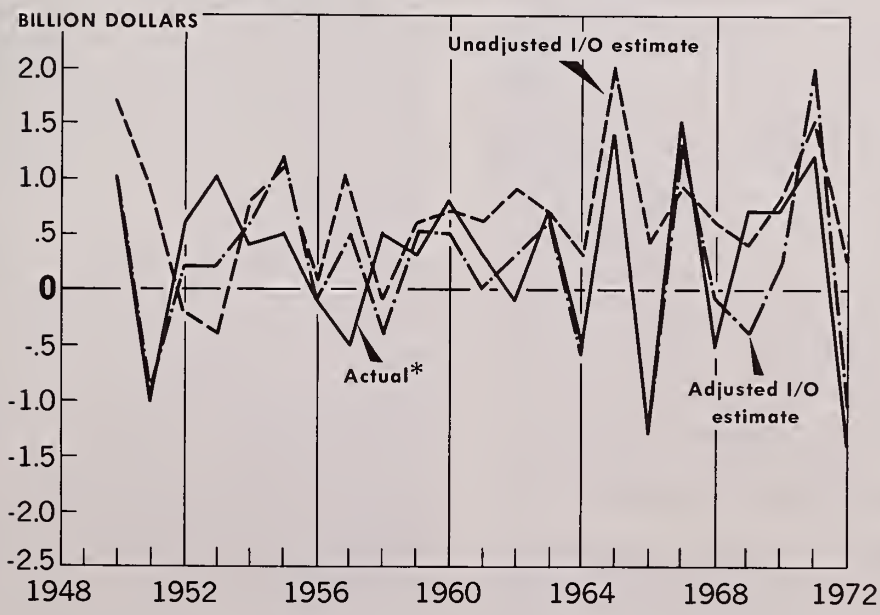
GROSS FARM PRODUCT, 1958 DOLLARS
Actual and Two Input-Output Estimates



*SOURCE: U.S. DEPARTMENT OF COMMERCE, SURVEY OF CURRENT BUSINESS, VARIOUS ISSUES.

Figure 1

CHANGES IN GROSS FARM PRODUCT, 1958 DOLLARS
Actual and Two Input-Output Estimates



*SOURCE: U.S. DEPARTMENT OF COMMERCE, SURVEY OF CURRENT BUSINESS, VARIOUS ISSUES.

Figure 2

"Adjusted" Input-Output Based Model

Several alternatives could be explored to deal with this characteristic "exploding" deviation pattern, which seriously limits its usefulness in a projection system. An attempt could be made to update the input-output matrix or reexamine the national income and product accounts for evidence of changes in product mixes within the various categories. The alternative chosen here involves less detailed adjustments. The technique chosen is the grafting of a regression equation onto the input-output based model as a means of compensating for the exploding deviation pattern.

The logic behind an adjustment equation on an input-output based model is basically that one knows certain structural coefficients are changing but, lacking sufficient data to specify individual coefficient changes, one attempts to estimate a gross adjustment. Sources of error in input-output projection models often arise in the violation of the assumption of a stable technology matrix which implies stable relative prices, stable production techniques, and a constant product mix within and between the sectors.

The adjustment equation proposed for the model attempts to reflect the influence of three forces upon the interrelationships between the agricultural sector and the rest of the economy. These forces are the influence of changes in relative prices, the impact of changing production technology and the resulting changing farm input mix, and the stage of development of the economy. The combination of the ratio of the implicit price deflator for gross farm product to the deflator for gross national product as a proxy for relative price effects, the index of farm output per unit of farm input as a proxy for the effect of changing technology, and a simple time trend as a proxy for stage of development provided the most effective adjustment for the deficiencies of the I/O based model. The adjustment equation for the constant dollar gross farm product prediction model (t-value in parentheses) is:

$$(GFP - G\hat{F}P) = 38.06249 - \underset{(6.1)}{0.06203}\,\frac{PGFP}{PGNP} + \underset{(2.9)}{0.15013}\,INDEX - \underset{(8.9)}{0.75284}\,T$$

$R^2 = 0.97 \qquad$ Durbin-Watson $= 1.36$

where

GFP = gross farm product in 1958 dollars
$G\hat{F}P$ = I/O based model estimate of GFP
$PGFP$ = implicit price deflator for gross farm product
$PGNP$ = implicit price deflator for gross national product
$INDEX$ = the index of farm output per unit of farm input
T = time, last two digits of year

Other variables considered were the parity ratio as a proxy for relative prices, the index of nonpurchased inputs as a proxy for changing production technology, and disposable per capita personal income (in 1958 dollars) as a proxy for stage of development.

The influence of shifts in relative prices and changing production technology would cause a violation of the assumption of fixed production coefficients and thus are forces which should be accounted for in the adjustment equation. Likewise, it is a natural consequence of the development of an economy for natural resource based sectors such as agriculture to diminish in relative proportion to the rest of the economy. This is an important force to consider in any adjustment procedure to an I/O based prediction model. In an economy experiencing a relatively stable rate of growth, a simple time trend may be a suitable proxy for rate of development and as a variable in the adjustment equation its performance is superior to the real per capita disposable income.

The adjustment equation was fitted on 1949-68 data to permit a 4-year period, 1969-72, for evaluation of the predictive ability of this model outside its period of fit. The results of the adjusted I/O model are presented in figure 1 and table 2. The adjustment equation has improved the predictive ability of the unadjusted model. The tendency for the model to overestimate gross farm product, apparent in figure 1, has been eliminated. This results in a dramatic drop in the root mean square predictive error,

$$\left[\frac{1}{20}\sum_{i=1}^{20}(P_i - A_i)^2\right]^{.5},$$

from 2.29 to 0.37 during 1949-68 and from 4.11 to 0.90 during the 1969-72 period of validation.

For short-term forecasting purposes, it is important for a model to predict changes as well as absolute levels of economic activity. Figure 2 and table 2 compare actual changes in constant dollar gross farm product with the predictions of the I/O based model and the adjusted I/O based model. The adjustment equation has improved the predictive ability of the I/O based model. It correctly predicted five of the seven decreases in GFP during the 1949-68 period of fit and the 1972 decrease during the validation period. It did erroneously predict a decrease from 1957 to 1958 within the period of fit and a 1968-69 decrease within the validation period. The root mean square prediction error (RMSPE) of the models' predictions of GFP changes was reduced from 0.93 to 0.44 during 1949-68 by the adjustment equation. The Theil U^2 statistic during this period was reduced from 1.38 to 0.31 with the adjustment equation. This low U^2 statistic indicates a superior predictive ability relative to the naive no-change hypothesis.

During the 1969-72 period of validation the adjusted I/O model was not as clearly superior to the performance of the unadjusted I/O model as a predictor of changes in the level of constant dollar gross farm product. The root mean square prediction errors during this period for the two models were 0.74 and 0.83, respectively, and they both had a turning point error during the period. With U^2 statistics of 0.50 and 0.63, both were better predictors than the naive no-change prediction.

Grafting an adjustment equation onto the I/O based model does improve the predictive performance of the unadjusted model. However, it compromises the inherent attribute of consistency of income estimates from an input-output model. Unless the analyst constructs similar adjustment equations for the rest of the economy and the net adjustment for the entire economy is zero, he can no longer be assured that the consistency of the individual sector estimates has been maintained. Therefore, one further comparison which must be made is the predictive performance of this adjusted I/O based model relative to a more direct estimation procedure for an estimator for gross farm product. Direct regression estimates fitted on the same data for 1949-68 did in fact do an equally good job of estimating actual gross farm product during the 1949-68 period of fit. However, during the 1969-72 validation period, the direct regression estimates consistently underestimated actual real gross farm product, and had three turning point errors, a root mean square prediction error of 1.64 on the estimates of the level of gross farm product, and a Theil U^2 statistic of 1.15 on the changes in the level. With RMSPE and U^2 statistics for the same period of 0.74 and 0.50, the adjusted I/O model exhibited a superior performance relative to the more direct approach.

Current Dollar Prediction Models

Although the level of real gross farm product is of interest to a limited number of economic analysts, projection estimates in nominal or current dollar terms are likely to be familiar to a broader audience. Input-output based estimates are by their nature real or constant dollar estimates, so current dollar projection estimates are not directly available from I/O based models. Two alternatives were explored to obtain current dollar estimates from the I/O based model. The first method utilized the adjustment equation approach to make the conversion to current dollars as well as to correct the tendency of the I/O based model to produce larger and larger deviations from actual levels as the period of time from the base year increases. The second approach was to estimate an equation which would predict the gross farm product implicit price deflator and apply this estimate to the adjusted I/O based model estimate of constant dollar gross farm product.

The adjustment equation used in the first approach was:

$$(GFP - \hat{GFP}) = 3.40752 - \underset{(8.4)}{0.11104}\ \frac{PGFP}{PGNP} - \underset{(1.1)}{0.07397}\ INDEX + \underset{(2.1)}{0.23398}T$$

$$R^2 = 0.96 \qquad \text{Durbin-Watson} = 1.26$$

The variables are the same as in the adjustment equation for the constant dollar estimates. The addition of this adjustment equation to the I/O based model estimates yields the series of estimates labeled "direct adjustment" in table 3 and figure 3.

The second approach required the estimation of an equation for the implicit price deflator for gross farm product. The equation used was:

$$PGFP = -34.30686 + 0.50562\,PR \atop (28.2)$$

$$+ 0.02468\,PP \atop (2.1)$$

$R^2 = 0.98$ Durbin-Watson = 1.21

where

PGFF = implicit price deflator for gross farm product

PR = index of prices received by farmers, 1910-14 = 100

PP = index of prices paid by farmers for all items including interest, taxes, and wages, 1910-14 = 100.[6]

This estimated price deflator was applied to the previously discussed adjusted I/O based model estimates of real gross farm product to yield the current dollar gross farm product series labeled "deflated adjustment" in table 3 and figure 3.

The results of the application of these two estimation procedures for current dollar gross farm product, together with the official U.S. Department of Commerce estimates, are shown in figures 3 and 4 and in table 3. During the period of fit for the equations (1949-68), both procedures performed similarly and did an adequate job of estimating the actual series. This graphical impression is borne out by selected analytical statistics. The root mean square prediction errors for the separate deflator procedure and the direct adjustment equation procedure were 0.4522 and 0.5015, respectively, for the level of activity and 0.5795 and 0.5781 for the annual changes. The Theil U^2 statistics were 0.1781 and 0.1773.

As would be expected, neither procedure did as well in predicting the level of change in this measure of economic activity outside the period of fit. During the validation period, 1969-72, the direct adjustment equation approach failed to predict the steady growth in gross farm product experienced during this period. In 1972, predictions using this procedure were \$6 billion low and only \$1.4 billion of the \$4.0 billion increase between 1971 and 1972 had been predicted. The separate deflator procedure did better. After underestimating the 1968-69 change, it exactly predicted the 1969-70 change, overestimated the 1970-71 change by an offsetting amount to the 1968-69 change, and predicted \$3.1 of the \$4.0 billion jump in gross farm product from 1971 to 1972. As a result, during the last 2 years of the validation period, this procedure gave estimates very close to the actual levels. On the basis of its overall performance, the separate deflator procedure appears to be superior to the direct adjustment equation approach and an acceptable short-run forecaster of current dollar gross farm product.

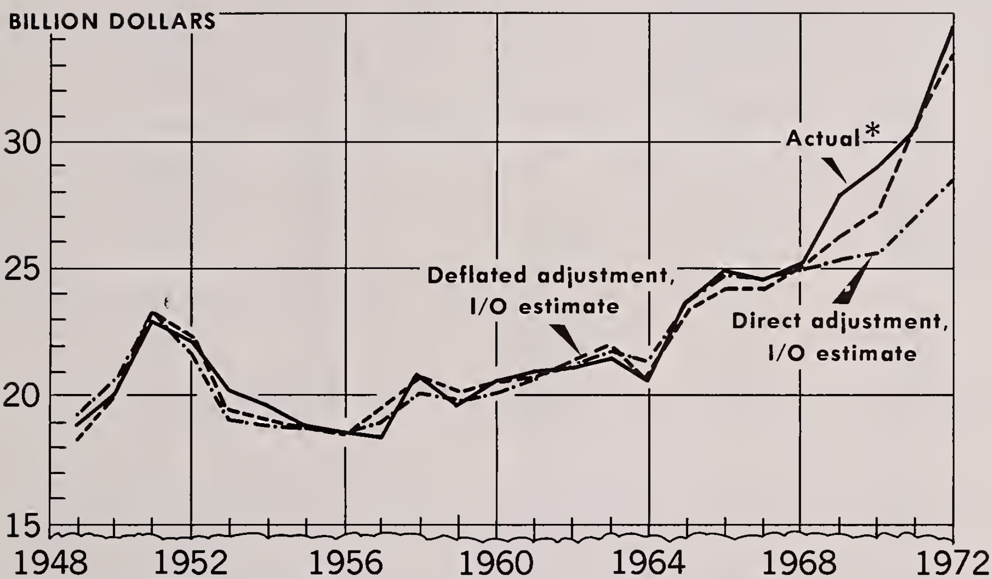
Conclusion

Neglect by the agricultural economics profession of the use of input-output analysis as more than a descriptive tool appears to have been an unfortunate oversight. With several modifications in usual input-output projections procedures, an input-output based model can be an acceptable short-range forecaster of economic activity. In addition, the modification allows one to avoid the massive data manipulation problems associated with the traditional I/O projection techniques with detailed tables, without sacrificing the utilization of the vast information available from these tables.

Gross farm product both in real terms and in constant dollar terms was a volatile component of the U.S. national income and product accounts during 1949-72. Such an economic series provides a rigorous test of the capabilities of an economic forecasting model. It was demonstrated that an input-output model with an adjustment equation to allow for forces which violate the static assumption underlying input-output models could be used as a short-term forecasting model for constant dollar gross farm product. Independently estimating an implicit price deflator for gross farm product

[6] Since the statistic for which the implicit price deflator is being estimated is the difference between gross farm income and intermediate products consumed in farm production, the index of prices paid by farmers for all production items would be the logical prices paid index to use in this equation. However, for the period of fit, the coefficient on this variable was not significant. Thus, the above alternative prices paid series was used.

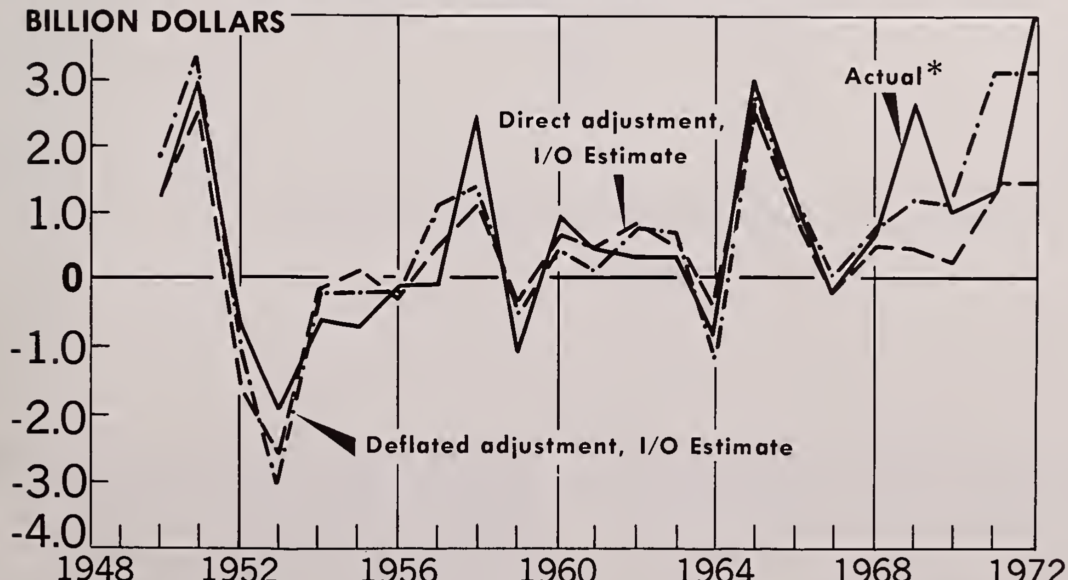
GROSS FARM PRODUCT, CURRENT DOLLARS
Actual and Two Input-Output Estimates



*SOURCE: U.S. DEPARTMENT OF COMMERCE, SURVEY OF CURRENT BUSINESS, VARIOUS ISSUES.

Figure 3

CHANGES IN GROSS FARM PRODUCT, CURRENT DOLLARS
Actual and Two Input-Output Estimates



*SOURCE: U.S. DEPARTMENT OF COMMERCE, SURVEY OF CURRENT BUSINESS, VARIOUS ISSUES.

Figure 4

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Table 3. Current dollar gross farm product: Actual series and two alternative estimation procedures, level and annual changes, 1949-72

(In billions of dollars)

Year	Level			Changes		
	Actual[a]	Direct adjustment	Deflated adjustment	Actual	Direct adjustment	Deflated adjustment
1949	18.8	19.3	18.3			
1950	20.0	20.7	20.1	1.2	1.4	1.8
1951	22.9	23.3	23.4	2.9	2.6	3.3
1952	22.2	21.7	22.4	–.7	–1.6	–1.0
1953	20.3	19.1	19.4	–1.9	–2.6	–3.0
1954	19.6	18.9	19.1	–.7	–.2	–.3
1955	18.8	19.0	18.8	–.8	.1	–.3
1956	18.6	18.6	18.5	–.2	–.4	–.3
1957	18.4	19.0	19.5	–.2	.4	1.0
1958	20.8	20.1	20.8	2.4	1.1	1.3
1959	19.6	19.7	20.2	–1.2	–.4	–.6
1960	20.5	20.2	20.6	.9	.5	.4
1961	20.9	20.6	20.7	.4	.4	.1
1962	21.2	21.4	21.4	.3	.8	.7
1963	21.5	21.8	22.0	.3	.4	.6
1964	20.6	21.4	20.7	–.9	–.4	–1.3
1965	23.7	23.9	23.4	3.1	2.5	2.7
1966	24.9	24.8	24.3	1.2	.9	.9
1967	24.6	24.5	24.3	–.3	–.3	0
1968	25.2	25.0	25.1	.6	.5	.8
1969	27.9	25.4	26.3	2.7	.4	1.2
1970	29.0	25.6	27.4	1.1	.2	1.1
1971	30.4	27.0	30.5	1.4	1.4	3.1
1972	34.4	28.4	33.6	4.0	1.4	3.1
RMSPE:						
1949-68		.50	.45		.58	.58
1969-72		4.01	1.20		1.79	1.22
U^2:						
1949-68					.18	.18
1969-72					.49	.22

[a]Source: U.S. Department of Commerce, *Survey of Current Business*, various issues.

and applying this estimate to the constant dollar gross farm product estimates allows estimates of current dollar gross farm product to be made.

The model was fitted on 1947-68 data to allow several years of data to be used as a validation period for the models. This validation period provided a particularly rigorous test for the model. Between 1971 and 1972, constant dollar gross farm product fell $1.4 billion while current dollar gross farm product rose $4.0 billion. The models accurately predicted the direction of each of these changes and predicted $1.1 and $3.1 billion, respectively, as their magnitude.

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Shifts in Cropland Use in the North Central Region*

By Jerry A. Sharples and Rodney Walker

An empirical model accurately estimates row crop and extensive crop acreage in the North Central region. It shows (a) for each 1-acre increase in diversion, row crops decrease 0.62 acre and extensive crops decrease 0.12 acre, and (b) the annual shift to row crops is diminishing.

Key words: Soybeans, corn, acreage, North Central region, regression analysis, time series.

What's the future for corn and soybeans in the Midwest? Have both crops reached their acreage limit? In 1954 farmers planted 57 million acres to corn and soybeans combined. By 1973 they planted 80 million acres to the two crops, with soybeans accounting for most of the increase. The additional acres came out of hay land and small grains. Can we expect this shift to continue? The answer is vital to predictions of future corn and soybean acreage.

This paper reports an empirical examination of shifts in cropland use in the North Central region.[1] The model can be used to make short-run predictions of row crop acres (corn and soybeans combined)[2] and combined extensive crop acres (wheat, oats, barley, rye, flax, and tame hay). The remaining sections of the paper contain a description and evaluation of the model.

Conceptual Model

The conceptual model attempts to account for the impact of two major factors on planted acreage: (1) the change in crop rotations over time, and (2) cropland diversion. The purpose of the model is to make short-run predictions of planted acreage of row crops and extensive crops in the North Central region, given various levels of annually diverted acreage.

Changes in crop rotations

During the 1960's substantial acreage in the North Central States shifted out of the extensive crops into corn and soybeans. The higher profit incentive from corn and soybeans plus changes in technology encouraged farmers to change traditional farming practices to increase their income. Hieronymus noted this shift toward corn and soybeans in 1969 but he speculated that the shift was about over (*4*). He thought that hay, oat, and wheat acreage remaining in the late 1960's was primarily on the poorer quality land—land not suited for continuous row crops. Finke and Swanson also noted the increase in soybean and corn acreages over time and characterized the trend as being primarily due to the "decline in the practice of rotations containing standover legumes" and the increasing profitability of corn and soybeans relative to oats, wheat, hay, and other crops (*2*).

New technology was available and being used by some farmers in 1961—the beginning of the period of analysis. Agronomic practices being used by innovators allowed continuous row crops on good land and increased row crops on the poorer land. The economic incentive to shift to row crops existed throughout the period. The net returns per acre of corn and soybeans greatly exceeded net returns on the extensive crops. Given the technology and the economic incentive, farmers shifted land use to row crops at a rapid rate during the early 1960's, but in recent years approached the limit of land suitable for row crops with present technology.

To model this process, a Spillman-type functional relationship was hypothesized to describe farmers' shift of land to row crops over time. The Spillman function had the desirable characteristics of (a) having an upper (or lower) limit, and (b) approaching that limit asymptotically, that is, row crops increase rapidly at first and increase more slowly as some upper limit (land suitable for row crops) is

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[1] Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.

[2] Since row crops such as grain sorghum, popcorn, sugarbeets, potatoes, and vegetables account for less than 4 percent of all row crops, they were not included in the analysis.

approached. Conversely, cropland inextensive crops decreases rapidly at first but then more slowly as a lower limit is approached. For a more complete explanation of the Spillman function see Heady and Dillon (*3*).

Diversion

A second factor that is hypothesized to have an impact on the acreage of row crops and extensive crops is the acreage diverted from crop production by the wheat and feed grain programs. From 1961 (first year of the feed grain program) to 1972, farmers in the North Central region diverted between 4 and 18 million acres annually under the two programs. Most of the diversion was due to the feed grain program. Wheat diversion never exceeded 2 million acres.[3]

The Agricultural Act of 1970 (effective during 1971-73) changed the rules for diverting cropland. No longer did a farmer with a corn base have to restrict his corn acreage to the base acreage less the diverted acreage to comply. Thus, it was hypothesized that in 1971 there would be an upward shift in the trend of row crop acreage because farmers could plant corn in excess of previous plantings and still comply with the feed grain program. The increased corn acreage would not all come at the expense of soybean acreage and the acreage in extensive crops was hypothesized to be below trend for 1971 and 1972.

Economic variables

Preliminary testing indicated that over the period of analysis, economic variables were of little value in explaining shifts in cropland use. This is not very surprising since cost, price, and profit relationships among competing crops were fairly stable during 1961-72. For example, net returns per acre of corn and soybeans greatly exceeded net returns of extensive crops in most of the North Central Region throughout the period of analysis. Relative to this profit gap, year-to-year changes in relative profits were small. Thus economic variables were not included in the final model. Data from 1973 and later years, however, should provide considerable fluctuation in the economic variables and should be added to the analysis when available.

[3]The cotton program required diversion in 5 of the years in the sample period, but the diversion never exceeded 100,000 acres in the North Central States—virtually all in southeast Missouri.

The Empirical Model

Utilizing the above conceptual model, a statistical model was specified as shown below.

$$(1)\quad Y_R = a_0 + \beta_1[a_1 + \beta_2(\beta_3)^T] + \beta_4(DVRN) + \beta_5(CFP) + \epsilon$$

$$(2)\quad Y_E = a_0 + \beta_1[a_1 + \beta_2(\beta_3)^T] + \beta_4(DVRN) + \beta_5(CFP) + \epsilon$$

where

Y_R = planted acres (in thousands) of row crops,
Y_E = planted acres (in thousands) of extensive crops including wheat, oats, barley, rye and flax, and harvested hay.
T = time expressed as 1961=1, 1962=2, . . ., 1972=12,
$DVRN$ = wheat, feed grain, and cotton diverted acres (in thousands),
CFP = a zero-one variable representing change of farm programs in 1971 eliminating planting restrictions on individual crops (1961-70 = 0, 1971-72 = 1),
$a_0,\ a_1,\ \beta_1,\ \beta_2, \ldots \beta_5$ = coefficients to be estimated,
ϵ = random disturbance terms.

The term $a_1 + \beta_2(\beta_3)^T$ represents the Spillman-type asymptotic shift of land into (out of) row crops (extensive crops). In equation (1), a_1 represents the upper limit of cropland suited for row crops. Over time this limit will be approached asymptotically. The coefficient β_3 should lie between 0 and 1 and β_2 should be negative. In equation (2), a_1 represents a lower limit of acreage suitable for extensive crops. Over time this lower limit will also be approached asymptotically. The coefficient β_3 in this equation should also lie between 0 and 1

and the coefficient β_2 should be positive.

The coefficient (β_4) on the diversion variable ($DVRN$) should be between -1 and 0 in both equations, indicating that an increase in diversion of 1 acre will reduce crop acreage by some fraction of an acre. The coefficient on the zero-one variable (CFP) should be positive in equation (1) and negative in equation (2) to indicate a one-time acreage shift out of extensive crops (into row crops) for 1971 and beyond.

Equations (1) and (2) can be viewed as two estimates of the same phenomenon—the shift of land from extensive crops to row crops. The decrease in extensive crops (Y_E) is expected to approximate the increase in row crops (Y_R) over time except for the land diverted out of crops by Government programs. Less than 2 percent of the cropland harvested in the North Central States is in crops other than the eight included in this study, so changes in other crops' acreage would have little influence on the major crops.

A simultaneous system of equations has intuitive appeal in this case because of the competition among crops for a limited quantity of cropland. The complexity of the estimation procedures, however, eliminated this possibility and forced us to use the simpler single-equation techniques.

Since equations (1) and (2) are nonlinear in the parameters, the impact of the three exogenous variables (T, $DVRN$, and CFP) could not be estimated using traditional linear estimating techniques. Nonlinear techniques were tried but the algorithms were unsatisfactory for our needs. Consequently, a two-step estimating procedure was utilized. For both type crops, the dependent variables (Y_R, Y_E) were first regressed on time using the following equations:

$$(3)\quad Y_R = a_1 + \beta_2(\beta_3)^T + \epsilon$$

$$(4)\quad Y_E = a_1 + \beta_2(\beta_3)^T + \epsilon$$

The actual dependent variables (Y_R and Y_E) were then regressed on the predicted values ($\hat{Y}_R$ and $\hat{Y}_E$) obtained from equations (3) and (4), diversion, and the zero-one variable as follows:

$$(5)\quad Y_R = a_0 + \beta_1 \hat{Y}_R + \beta_4 (DVRN) + \beta_5 (CFP) + \epsilon$$

$$(6)\quad Y_E = a_0 + \beta_1 \hat{Y}_E + \beta_4 (DVRN) + \beta_5 (CFP) + \epsilon$$

Consequently, values of β_1 in equations (5) and (6) are not expected to differ significantly from 1.0.[4]

An asymptotic regression algorithm was used to estimate the parameters for equations (3) and (4).[5] The estimated equations are:

$$(7)\quad Y_R = 75{,}404 - 21{,}197(0.8748)^T \qquad R^2 = 0.86$$

$$(8)\quad Y_E = 22{,}996 + 27{,}601(0.9276)^T \qquad R^2 = 0.98$$

In equation (7), the estimate of β_2 has the expected sign. The estimate of β_3 is less than 1.0, indicating that row crop acreage (Y_R) will increase at a decreasing rate over time and approach a maximum. The estimate of β_2 in equation (8) has the expected sign and the coefficient of β_3 indicates that acreage will decrease at a decreasing rate toward a minimum.

The predicted values obtained from equations (7) and (8) were used as independent variables (along with $DVRN$ and CFP) and estimated by ordinary least squares to obtain an ordinary least squares estimate of the parameters for equations (5) and (6). The resulting equations are:

$$(9)\quad Y_R = 2141 + \underset{(0.086)}{1.094}\,(\hat{Y}_R) - \underset{(0.101)}{0.621}\,(DVRN) + \underset{(855.5)}{718.74}(CFP) \qquad R^2 = 0.97$$

$$(10)\quad Y_E = 2432 + \underset{(0.061)}{0.980}\,(\hat{Y}_E) - \underset{(0.082)}{0.120}\,(DVRN) + \underset{(691)}{137}(CFP) \qquad R^2 = 0.98$$

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[4] From the method of estimation used for equation (3), $\hat{Y}_R$, the predicted values from equation (3), are unbiased estimates of Y_R. If $\hat{Y}_R$ is not correlated over time with $DVRN$ or CFP, then in equation (5), β_1 will equal 1.0. The higher the correlation between $\hat{Y}_R$ and the other independent variables, the more β_1 will deviate from 1.0.

[5] See (*1*, p. 297).

Numbers in parentheses are the standard errors of the estimated coefficients. Because of the insignificant size of the coefficient for (*CFP*) in relation to its standard error in equation (10), that variable was omitted and the equation reestimated to give:

$$(11)\quad Y_E = \underset{}{2815} + \underset{(0.046)}{0.972}\,(\hat{Y}_E) - \underset{(0.075)}{0.124}\,(DVRN) \qquad R^2 = 0.98$$

Substituting (7) into (9) and (8) into (11) for the $\hat{Y}_R$ and $\hat{Y}_E$ terms, respectively, and simplifying, yields:[6]

$$(12)\quad Y_R = 84{,}184 - 22{,}746\,(0.8748)^T - 0.621\,(DVRN) + 1260\,(CFP)$$

$$(13)\quad Y_E = 25{,}167 + 26{,}828\,(0.9276)^T - 0.124\,(DVRN)$$

Equations (12) and (13) are the equations used for predictive purposes.

Implications

Several implications may be drawn from equations (12) and (13). First, the R^2 values and predicted versus actual values shown in figure 1 indicate that the equations accurately fit the sample data. The largest deviation in the estimate of row crop acreage was 2 percent (1.2 million acres) in 1965 and in only 2 years, 1963 and 1965, was the deviation in excess of 1 million acres. For extensive crops the largest deviation was 3 percent (1 million acres) in 1968.

Second, the addition of the diverted acres and zero-one variables accounted for most of the deviation of the annual row crop acreages from the asymptotic trend line, and raised the R^2 from 0.86 in equation (7) to 0.97 in equation (9). The addition of the diverted acres variable to the extensive crops equation had little impact. Equation (9) indicates that after

[6] This two-step estimating procedure would give misleading estimates of the coefficients for the time variable and the set-aside variable if set-aside were correlated with time. The simple correlation coefficient between time and set-aside was 0.38; low enough to indicate that this was not a problem.

ACTUAL AND ESTIMATED INTENSIVE AND EXTENSIVE CROP ACREAGES, NORTH CENTRAL REGION

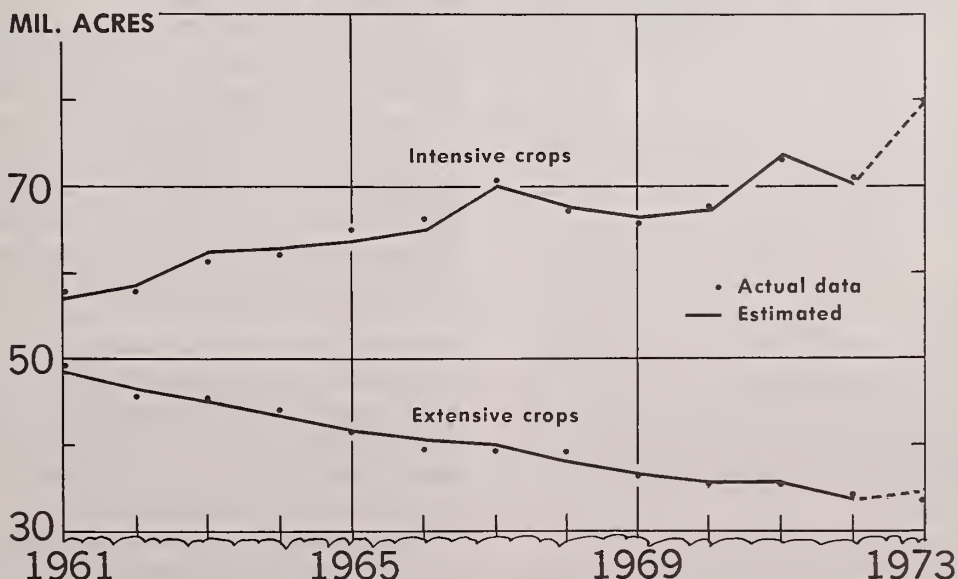

Figure 1

accounting for trend, there was a decrease of 0.621 acre of row crops for each acre increase in diversion. During the 1960's most of the impact of an increase in diversion was on the corn portion of the row crops, but with the set-aside programs of 1971 and 1972, the diversion acreage could be taken from any crop.

In 1973 the Agricultural Stabilization and Conservation Service made a survey of 982 farms across the country. One question asked was, "How do you plan to use the 1973 set-aside land in 1974?" All 1973 set-aside acreage is available for use in 1974. In the North Central region the survey showed that farmers planned to plant 67 percent of the 1973 set-aside land to corn or soybeans in 1974—57 percent to corn and 10 percent to soybeans. This survey estimate is equivalent in definition to the coefficient on the diversion variable in the row crop equation and lends credence to the estimated value (0.621) of that coefficient.

Third, equations (12) and (13) can be used to estimate the trend in cropland shifted from extensive crops to row crops. This is done by holding (*DVRN*) and (*CFP*) constant and evaluating with sequential values from time (*T*). The shift between selected years is shown in table 1. The estimated equations show that during the early 1960's the shift to row crops was large and decreased over time. The opposite occurs for extensive crops. However, the two time trends are not mirror images of each other, that is, the incfease in row crops has not been equal to the decrease in extensive crops.

Table 1. Estimated trend change in row crops and extensive crops, selected years, North Central region

Period of change	Row crops[a]	Extensive crops[a]
	1,000 acres	*1,000 acres*
1961 to 1962	2,492	−1,803
1971 to 1972	652	−850
1972 to 1973	574	−789
1981 to 1982	172	−401

[a]The tabular numbers were obtained assigning values of $DVRN = 0$ in equations (12) and (13) and $CFP = 1$ in equation (13).

Estimates of the upper limit on intensive acreage and the lower limit on extensive acreage may be obtained by setting time (*T*) to infinity. This results in an upper bound on corn and soybean acreage of 85.4 million acres (5.4 million acres above the 1973 acreage) and a lower bound on extensive crop acreage of 25.2 million acres (8.7 million acres below 1973). These estimates indicate that a relatively small shift in cropland can be expected in future years.

These upper and lower bound estimates are critical to the usefulness of equations (12) and (13) for making longer run predictions. An analysis of the Conservation Needs Inventory data by Martin and Van Arsdall indicates that about 100 million acres would be a reasonable upper bound on corn and soybean acres, assuming present technology and accepted conservation practices (*5*). Compared with this estimate, the 85.4-million-acre estimate is low and suggests that predictions from equation (12) may be low. The converse would be true for equation (13).

Equations (12) and (13) are useful for estimating expected response to various levels of feed grain and wheat set-aside acreage in 1973. The change in row crop acreage can be divided into two parts: (1) that which is not responsive to annual changes in the programs (the trend component), and (2) that which is responsive to the programs (the diversion component). For 1973 the trend component adds 574,000 acres to row crops over 1972 and each acre reduction of set-aside below 1972 acreage adds 0.621 acre.

Predictions for 1973 are made using the two equations (see figure 1). Diverted acreage under the wheat, cotton and feed grain programs was 3.8 million acres. Equation (12) underestimated row crops by 1,080,000 acres or 1.3 percent. Equation (13) overestimated extensive crops by 596,000 acres or 1.7 percent. These small deviations are probably due to farmers' response to commodity price levels for 1973, which were substantially above those of previous years. The accuracy of these estimates is especially significant because of the major change in 1973 farm programs. Eighty percent (13 million acres) of the 1972 set-aside in the North Central States was released in 1973 and the model accurately predicted the row crop response.

The estimation of individual crop acreages is more difficult. It requires detailed knowledge of the wheat and feed grain programs and their cross-effects on other crops. Other factors

Table 2. Data used in acreage analysis, North Central States, 1961-73

Year	Time (T)	Zero-one variable (CFP)[a]	All diversion ($DVRN$)[b]	Row crops (Y_R)[c]	Extensive crops (Y_E)[d]	Estimates of (Y_R)[e]	Estimates of (Y_E)[f]
			1,000 acres	*1,000 acres*	*1,000 acres*	*1,000 acres*	*1,000 acres*
1961	1	0	11,742	57,623	49,074	56,994	48,596
1962	2	0	13,803	58,011	45,602	58,205	46,539
1963	3	0	10,830	61,218	45,369	62,230	45,236
1964	4	0	13,200	62,229	44,236	62,665	43,392
1965	5	0	14,454	65,005	41,840	63,554	41,799
1966	6	0	14,461	66,178	39,686	65,009	40,464
1967	7	0	8,487	70,798	39,610	69,995	39,967
1968	8	0	14,260	67,247	39,156	67,527	38,104
1969	9	0	17,615	65,904	36,412	66,420	36,623
1970	10	0	16,860	67,942	35,425	67,743	35,729
1971	11	1	10,347	73,310	35,447	73,795	35,620
1972	12	1	17,207	71,307	34,328	70,189	33,920
1973[g]	13	1	3,865	80,126	34,190	79,046	34,786

[a]Farm programs changed to remove restraints on planted acres of individual crops.
[b]Feed grain, wheat and cotton diversion.
[c]Corn and soybean acreas planted.
[d]Planted acres of oats, wheat, barley, rye and flax, and harvested acres of tame hay.
[e]Estimated values for corn and soybean acreas planted.
[f]Estimated values for planted acres of oats, wheat, barley, rye and flax, and harvested acres of tame hay.
[g]Not used for estimating.

affecting the acreage response of individual crops must also be identified and assessed. But the problem of individual crop estimation is aided by having a reliable estimate of the acreage in row crops and extensive crops.

Conclusions

Four main conclusions are derived from this analysis:

(a) Since 1961, considerable acreage has shifted from extensive crops, such as wheat, oats, and barley, to corn and soybeans in the North Central States. Even though the annual shift is estimated to be much smaller now than during the early 1960's, it should be considered when predictions of future crop production are made.

(b) For each acre increase in diversion or set-aside, row crop acreage decreases about 0.62 acre and extensive crops decrease about 0.12 acre. The remaining 0.26 acre comes from other land uses.

(c) The model demonstrates the ability to predict accurately cropland planted to two crop categories—row crops and extensive crops. Prediction of planted acreage of individual crops can be made more accurately once a reliable prediction of these two groups of crops is obtained.

(d) In the future, economic variables could play a more direct and important role in explaining crop acres while the impact of the shift of cropland should be diminished. However, this paper indicates that future models of crop production in the North Central Region should incorporate a measure of cropland shifting to the row crops during the 1960's.

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BOOK REVIEWS

The Tender Carnivore and the Sacred Game

By Paul Shepard. Charles Scribner's Sons, 597 Fifth Avenue, New York 10017. 302 pages. 1973. $9.95.

In *The Economy of Cities*, Jane Jacobs argued that only prehistoric city dwellers could have been smart enough and progressive enough to have invented agriculture some 10,000 years ago. By contrast, Paul Shepard argues in this book that cities are just a further compounding of the evils of agriculture, the invention of which constituted the worst ecological disaster ever to befall this planet. Shepard believes that man's primate forebears and his 2 million years as a hunter-gatherer are the sources of the meaning of human experience, and that man's most cherished qualities and abilities are products of his hunting and gathering existence. The agricultural and industrial societies of recent times—and they are *very* recent in terms of man's evolutionary history—have been the total negation of all that went before. So Shepard advocates the abandonment of upstart agriculture as a rapidly proliferating excrescence on the face of the earth. He would then propose the separation of technology from land use and the perfection of this technology in the production of food and fiber in factories from cultures of one-celled organisms, thereby leaving present agricultural land free for a giant hunting preserve—so that man could return to his true nature!

This is not as ridiculous as it sounds. The first seven-eighths of the 280-page text are devoted to (1) preagricultural hunting as a way of life; (2) 10,000 years of drudgery, war, slavery, and ecological destruction, all resulting from the adoption of agriculture; and (3) the inevitably high current significance of man's having been shaped by the past. Shepard is quite convincing in all of this. The remaining text is about evenly divided between a diatribe against present-day commercial agriculture, also fairly convincing, and an attempt to outline a solution to the overwhelming problems that have been presented. This last effort, covering less than 20 pages, is not very convincing. But Shepard would doubtless reply that the world is too far gone for easy solutions, and that only a far-out solution will work. His is certainly that.

The "tender carnivore" of the title is us, of course, together with our ancestors for millions of years in the past; and the "sacred game" refers to the symbiotic relationship between the hunter and the hunted, and to the resulting psychological and religious (totemic) role of animals in human evolution. That role was clearly so great, in fact, that the real mystery of domestication is not *how* men achieved control of plants and animals, but *why*. "All major human characteristics—size, metabolism, sexual and reproductive behavior, intuition, intelligence—had come into existence [as a result of] and were oriented to the hunting life" (p. 7). The collapse of that life must have affected the very heart of human existence. Why did it occur?

No one knows the answer. All that can be said for certain is that there must have been a powerful incentive, and this reviewer, as an economist, may surely be pardoned for assuming it to have been economic in nature. Man had always hunted cooperatively in groups, and there is no doubt that, during the successive advances and recessions of polar ice, these hunting groups had become extremely efficient. During the last ice age, some species of game animals—the mammoth, to name just one—mysteriously disappeared, a phenomenon that has been referred to as the "Pleistocene overkill" (Paul S. Martin, *Natural History*, Dec. 1967). Thus, in some areas at least, man may have had little choice but to augment the "gathering" aspects of his previous hunting and gathering existence, eventually making a virtue of necessity and actually cultivating the crops.

Shepard is knowledgeable and perceptive, and he writes in a strongly worded style. A few quotations from his attacks on agriculture, especially "industrial agriculture," may give the

flavor: "Agriculture ceased to be voluntary and became coercive some 6,000 years ago, with the emergence of the autonomous, centralized political unit with power to collect taxes, draft workers and soldiers, and enforce law. . . . War emerged with the shift in ecology, which produced the arrogant concept of land ownership and the struggles for resources, space, and power."

On the nature of modern agriculture: "Modern animal science may be defined as the systematic creation of animal deformities, anomalies, and monsters, and the practice of keeping them alive. . . . Mediated by the county agent, technicians of government agricultural agencies, the bureaucrats of subsidy and marketing programs, the industry-dominated farm media, and all the 'agri-businessmen' together create rural Disneyland, a self-contained, self-explanatory, and self-judging sham. . . . The depersonalizing and socially destructive forces of the city can be traced to their true origins: the country."

On economics and the universities: "It can be convincingly shown that forest conservation will be practiced by forest industries and soil conservation by farmers as these become economically imperative, that the decline in natural resources will gradually be leveled by rising economic incentive. Such arguments can be so neatly woven by professionals in the 'resource field' that one is struck with awe and admiration at their beautiful simplicity. The way in which self-correcting means are built in, the aura of destiny and inevitability, the justification of past and present that relieves us of responsibility are more than seductive; they are ravishing. For trapping the modern farmer and his wife within this dialectic we can thank academia—the land-grant universities."

On the Green Revolution: "The Green Revolution is moving to complete the industrialization of the earth's land and sea surfaces. . . . [It advocates that most of these surfaces] be refashioned after Iowa pig farms or Texas cotton ranches. . . . By impoverishing an already fragile habitat with uniform crop plants, it will create balances that cannot be kept, crops that cannot be protected, landscapes so foreign to a desert climate that their precarious existence will require ever-increasing inputs of chemical and mechanical control."

On women and agriculture: "Farming was a lifelong commitment to toil and drudgery in which the wife became part of the taxpayer's property. . . . No slaves were ever more cruelly exiled to hopeless toil. . . . The shame and psychological stress of barrenness, or the debilitating physiological effect of perpetual pregnancy and lactation, were women's share of the life of drudgery. . . . The farm woman [today] has been sold short [in that] she has been removed from the immediate scene of the farm. Her potential human and feminine reactions to the banality and monotonous horror of the new industrial farm are no longer a threat to its continuation. This is the Women's Auxiliary of the Green Revolution."

The solution proposed, to become effective over a period of 50 years or so, does not seem to be physically impossible. But it *is* politically and socially impossible given the present state of the world. Assuming 8 billion people on earth 50 years hence, they would live in 160,000 cities of 50,000 people each, constructed in a broken line inside a 5-mile-wide ribbon around the perimeter of each continent, leaving the interiors of the continents to nature and to the wilderness. Food would be produced in city factories underground, gardens would be permitted because they are horticulture, not agriculture, but eating and recreation would be in clan-sized groups of families—about 25 persons, including six adult males for a proper hunting group. Hunting would be done in groups, on foot, and with hand weapons only; it would be truly hazardous. Children would be introduced gradually to the wilderness, and adolescents to the hunting life.

As to the basic food supply, Shepard insists that microbes can do anything that higher organisms can do in making amino acids, vitamins, sugar, and other nutritional essentials, and that these would not be "artificial" foods, but new sources that already exist in nature. He notes that certain types of yeast produce a ton of pure protein from 2 tons of petroleum on which they are grown. At this rate, "the oil burned to operate the machinery of the present industrial farms would feed more people when channeled through yeasts than the farms now feed, and free the earth's skin from us as parasites" (pp. 261-2).

Present-day problems of violence, of personal alienation, and of environmental disorder seem to be getting worse, not better, and the answers

provided by technology and ideology seem unsatisfactory. Is it possible that we should return to prehistory and make a new start by reaffirming the "pre-man" or "pre-woman" in all of us?

This book is stimulating, even irritating, and should receive more attention than it has so far. Shepard calls himself a "naturalist," an old-fashioned term for a generalist in the natural sciences. His knowledge and insights have made his book controversial—some would say outrageous. But who knows for sure? Perhaps he has given us the only possible "scenario" for the future if the "tender carnivore" is to survive at all.

Ernest W. Grove

The Development of Rural America

Edited by George L. Brinkman. The University Press of Kansas, Lawrence, Kans., 66044. 140 pages. $8.50.

When one keeps hearing that "rural development is an idea whose time has come" without seeing that idea definitively explained in the literature, perhaps he may be forgiven if he appears eager to get his hands on a book bearing the title "The Development of Rural America." On the other hand, you may well say that anyone who judges a book by its title deserves to lose his $8.50.

Rural areas, according to the recent census, continue to have a higher incidence of poverty than urban ones; the expected income of a rural family remains lower; and rural-oriented regions continue to lag behind urban-oriented regions in economic development. These cold census statistics form an abstract, quantitative indicator of an important qualitative problem about prospects for the good life in rural areas.

There is some evidence in the census statistics that rural areas as a whole are tending to grow faster than urban areas, in the sense that income per capita is rising faster and the rural-urban income gap is narrowing. The pace of outmigration appears to be abating. If these growth trends continue, rural America may "catch up" to urban America during the next two or three decades. There is evidence that rural areas are developing in the sense of finding new ways of doing things. For example, rural residents are depending far less on agriculture as an economic base and are finding employment in a broad spectrum of rural nonfarm jobs. And there is evidence that rural areas are achieving progress in the sense that attitudes are changing to embrace a broader spectrum of possible solutions to the rural economic and social problems. For example, some rural areas are adopting a less parochial and more cosmopolitan approach to rural development.

Brinkman and his contributors bring out some of these facts which describe the current rural situation and the outlook, particularly in the chapters by Calvin Beale and George Brinkman. But the descriptive material suffers from failing to cover the total rural development scene and from failing to update the statements to include data available at the time of publication.

Theories which help to explain the accelerated growth rates in rural areas are abundant. The various theories are sometimes overlapping and reinforcing, sometimes they leave unexplained gaps, and sometimes they logically contradict one another. But together they touch upon most of the elements required to describe, explain, and abet rural development.

Some theories embrace the notion that a rural economy will pass sequentially through alternative *stages of growth.* Such theories have proven to have powerful descriptive value but no analytic power. *Market inducements* play a key role in some theories of rural growth. For example, base theory says growth depends on developing an export market for local products, and Keynesian theory says employment varies with aggregate demand. *Resource availabilities* are critical limits to growth in classical growth theories which base growth rates on increases in labor, capital, or land resources. Advances in *technology* which result in more output per unit of input form the basis of some growth theories. Consideration of *spatial relationships* leads to growth theories which depend on transportation prospects, propinquity, or agglomerative economies. *Institutional arrangements* are central in some theories of rural area growth. Such theories may point to the role of local organizations and to the attitudes of local leaders toward the growth process. Finally, there are the holistic approaches to growth which say we can't explain without analysis of the whole *system.*

Brinkman and his contributors fail to face up

to the problem of using theory to help explain the rural development problem and to provide the reader with a framework for understanding how rural areas grow. However, they do seek to describe the rural development process, particularly in the chapters by J. Carroll Bottum and Richard Hausler.

Many rural development strategies are currently in operation at the Federal, State, and local levels, and others are being considered by administrators and legislators. These policies include influences on population growth, migration, labor force participation, job creation, productivity, capital accumulation, market development, location, and institution building. Brinkman and his contributors bring some useful perspective to the policy dimension of rural development, particularly in the chapters by Luther Tweeten, Emery Castle, and Niles Hansen.

With all these facts, theories, and policies floating through the literature of rural development, it may not be too much to hope that one day a definitive book will point the way to describing rural development problems, explaining them, and ameliorating them. When that book arrives, it may well have a title similar to the text currently under review.

Brinkman's text is a collection of papers originally presented to students in an undergraduate course at Kansas State University in 1971. Six of the guest speakers contributed papers to this collection. It is a blue-ribbon list of contributors and there is no doubt that what they had to say was stimulating to the undergraduates in Kansas in 1971. One wonders to whom the 1974 book is addressed? Some of the articles are in simple English for layman audiences, and some employ matrix algebra or symbolic logic that will have meaning only to a limited audience.

But the basic question is: What do these authors have to say to us in 1974? Some of the material has been used constructively by the authors before and is already available to us in print. Some of the material is dated and the authors already have more recent versions in print. Each of the separate contributors to this volume had something interesting and useful to say relating to the rural development problem. But pasting these contributions together and binding them in hard covers doesn't make them into what the publishers called "an integrated approach to rural development." This reviewer is still waiting for a book with a similar title that really meets the publishers' objective.

Clark Edwards

U.S. Trade in the Sixties and Seventies

Edited by Kenneth Jameson and Roger Skurski. D.C. Heath and Company, 2700 North Richardt Avenue, Indianapolis, Ind., 46219. 137 pages. 1974. $12.50.

Trade relations among the world countries were different during the 1960's compared with the early 1970's. One obvious reason is the widespread emergence of multinational firms. Currently it is common practice for components of a product to be bought in Germany, the United States, Brazil, and France, and assembled in Taiwan and the Dominican Republic for export. The 1960's were a time of definite trade patterns set by the cold war; in the 1970's a trend can be seen toward normalization of trade with every country of the world (except perhaps Cuba).

The implication of the new turn in world trade is that the economies of the world are becoming less self-sufficient and more dependent on each other for their goods and services. Hopefully the increase in mutual trade would lead to the lessening of protectionism and the effective application of the theory of comparative advantage, thus leading to more efficient management of the earth's resources.

This book is an assembly of papers given at a conference entitled "Emerging International Trade Patterns of the United States," held at the University of Notre Dame in April 1973. It was an attempt to bring together the underlying trading relations between the United States and its world trading partners.

This reviewer was interested to learn about an important aspect of the economic miracle of Japan. Patricia Hagan Kuwayama explained that Japan's success is attributable in large part to government efforts directly encouraging exports. Banks of Japan offer short-term credit against export bills of preferential rates, and tax laws provide for tax exemptions. Furthermore, Japan's domestic market has been more protected against competition from foreign manufacturers than any other industrialized country in the postwar period.

As regards the traditional advantageous trade relations between the United States and Latin America, according to Kenneth Johnson, future trade relations will not be as bright for this country as they have been in the past. During the 12 years from 1960 to 1971, the United States was in a surplus position in trade of goods and services with Latin America—particularly Central America. It seems that a continuous surplus will not be the experience in the future. Johnson documents well the impending decline in the importance of the United States and Latin America to each other's trade—again mainly in Central America.

Roger Skurski contends that postwar American economic policy toward Eastern Europe and the Soviet Union is a history of an almost continuous conflict between the legislative and executive branches of our Government. The most recent example of this is the reluctance of the U.S. Senate to ratify the Soviet-American agreement which was signed in October 1972. Needless to say, there are many complex obstacles preventing a large and rapid expansion in U.S. trade with the Soviet Union and Eastern Europe, but in almost every case there are forces in operation to reduce the size of these obstacles.

In a paper on the future market of the People's Republic of China, Robert F. Dernberger writes interestingly about that country's economy. China's import demand and U.S. exports are complementary, but China's export supply and U.S. import demand are not. China's imports of producers' goods are severely curtailed by its capacity to obtain foreign exchange from its export trade. Without exception, China's trade policies do not adhere to the "price is right" principle. There is an encouraging note implicit in the paper about the prospects for world peace. Since the failure of the Great Leap Forward and the ensuing agricultural crisis reduced China's demand for producers' goods obtainable in the communist countries, China's trade is reverting to the West from the communist countries and is causing a break in the political relations with the Soviet Union.

Jack Ben-Rubin

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Suggestions for Submitting Manuscripts for Agricultural Economics Research

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2. CLEARANCE. Obtain any approval required in your own agency before sending your manuscript to one of the editors or assistant editors of Agricultural Economics Research.
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4. NUMBER OF COPIES. Submit one ribbon copy and two additional good copies of the article for review.
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